

Claims: I claim:

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1 1. A method for enhancing image quality comprising:
2 developing a usefulness metric which identifies a
3 limit to sharpness enhancement that can be applied to
4 decoded video without enhancing coding artifacts; and
5 applying the usefulness metric to at least one
6 sharpness enhancement algorithm, the usefulness metric and
7 the sharpness enhancement algorithm being separate such
8 that the usefulness metric can be used with a variety of
9 algorithms.

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1 2. A method for enhancing the sharpness of a coded digital
2 video, comprising the steps of:
3 selecting and extracting statistical information from
4 a coded video bit stream in order to identify the video's
5 coding complexity;
6 based upon the coding complexity, developing a
7 usefulness metric for the coded video, which identifies a
8 limit to sharpness enhancement that can be applied to the
9 coded video after it is decoded, without enhancing coding
10 artifacts; and

11. applying a sharpness enhancement algorithm to the
12 decoded video to increase sharpness within the limit
13 prescribed by the usefulness metric.

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1 3. The method as claimed in claim 2 wherein the sharpness
2 enhancement algorithm is a peaking algorithm

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1 4. The method as claimed in claim 2 wherein the sharpness
2 enhancement algorithm is a spatial-domain algorithm

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1 5. The method as claimed in claim 2 wherein the usefulness
2 metric is calculated on a pixel-by-pixel basis

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1 6. The method as claimed in claim 2 wherein the coding
2 complexity is defined as the product of a quantization
3 parameter and a number of bits used to code a macro block

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1 7. The method as claimed in claim 2 wherein the coding
2 complexity is defined as the product of a quantization
3 parameter and a number of bits used to code a block.

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1 8. The method as claimed in claim 2, wherein the usefulness
2 metric occupies a range, a first terminus of the range
3 meaning no sharpness enhancement is allowed for a

FOIA b 7 - D42650

4. particular pixel and second terminus of the range meaning
that the pixel can be freely enhanced

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1 9. The method as claimed in claim 2, wherein the method is
2 also applied to skipped macroblocks, the usefulness metric
3 being estimated based upon the coding complexity of
4 surrounding macro blocks or the coding complexity of a
5 previous frame

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1 10. The method as claimed in claim 2, wherein the method is
2 also applied to uncoded blocks, the usefulness metric being
3 estimated based upon the coding complexity of surrounding
4 blocks or the coding complexity of a previous frame

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1 11. The method as claimed in claim 2, wherein in addition
2 to the usefulness metric, scene-content related information
3 is incorporated into a coding gain calculation

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1 12. The method as claimed in claim 2, wherein the scene-
2 content related information is derived from edge
3 information

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1 13. The method as claimed in claim 5, wherein coding gain
2 of a pixel is determined by the equation:

3.
4 $g_{\text{coding}}(i,j) = \text{UME}(i,j) + g_{\text{edge}}(i,j)$
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7 and wherein i and j are pixel coordinates, g_{coding} is the
8 pixel coding gain, UME is the usefulness metric and g_{edge} is
9 based upon edge-related information derived from the image
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1 14. The method as claimed in claim 13, wherein spatial low-
2 pass filtering is applied to a complexity map calculated
3 from the coded digital video.
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1 15. The method as claimed in claim 13, wherein temporal
2 filtering is applied to the coding gain using the coding
3 gain of a previous frame
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1 16. The method as claimed in claim 13, wherein the equation
2 can be extended to include an additional term directly
3 related to the quantization parameter
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1 17. The method as claimed in claim 6, wherein a block-based
2 complexity map is filtered temporally using an IIR filter.
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1 18. The method as claimed in claim 6, wherein a macro
2 block-based complexity map is filtered temporally using an
3 IIR filter.

1 19. The method as claimed in claim 17 or 18, wherein the
 2 temporal filtering is in accordance with the following
 3 equation:

$$\begin{aligned} & \text{compl}_{\text{MB/block}}(r,s,t) = k * \text{compl}_{\text{MB/block}}(r,s,t) + \text{scal} * (1- \\ & k) * \text{compl}_{\text{MB/block}}(r,s,t-1) \end{aligned}$$

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 8 and wherein r,s is the spatial coordinate of a macro block
 9 or block, t represents the current picture, k is the IIR
 10 filter coefficient and scal is a scaling term taking into
 11 account picture complexity determined by the image's
 12 picture type.

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1 20. A device for image quality enhancement comprising:

2 a peaking filter which filters a decoded luminance
 3 signal, generating a high pass signal;

4 a plurality of pixel based control blocks, operating
 5 in parallel on the decoded luminance signal, each
 6 calculating a maximum allowable gain factor, based upon a
 7 characteristic of the luminance signal, wherein at least
 8 one control block is a coding gain block which implements a
 9 usefulness metric which determines the allowable amount of
 10 peaking;

11. a dynamic gain control for selecting a minimum gain
12 based upon the calculated maximum gain factors;
13 a multiplier for multiplying the high pass signal by
14 the minimum gain generating a multiplied signal; and
15 an adder for combining the decoded luminance signal
16 with the multiplied signal, generating an enhanced signal.

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1 21. A device as claimed in claim 22, wherein the control
2 blocks comprise:

3 a contrast control block;
4 a dynamic range control block;
5 a clipping prevention control block;
6 an adaptive coring control block; and
7 a coding gain block, all of the blocks being connected
8 in parallel

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1 22. A device for enhancing the image quality of a digital
2 video comprising:

3 a usefulness metric generator which identifies a limit
4 to sharpness enhancement that can be applied, without
5 enhancing coding artifacts, to decoded digital video;

6 a controller which applies the usefulness metric to at
7 least one sharpness enhancement algorithm, the usefulness
8 metric and the sharpness enhancement algorithm being

9. separate such that the usefulness metric can be used with a
variety of algorithms.

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1 23. A system which enhances sharpness of a coded digital
2 video, comprising:

3 a selector which selects and extracts statistical
4 information from a coded video bit stream in order to
5 identify the video's coding complexity;

6 a usefulness metric generator that, based upon the
7 coding complexity, develops a usefulness metric for the
8 coded digital video after decoding, which identifies a
9 limit to sharpness enhancement that can be applied to a
10 decoded video without enhancing coding artifacts; and

11 a sharpness enhancer which applies a sharpness
12 enhancement algorithm to the decoded video to increase
13 sharpness within the limit prescribed by the usefulness
14 metric.

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1 24. The system as claimed in claim 23, wherein the
2 sharpness enhancement algorithm is a peaking algorithm.

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1 25. The system as claimed in claim 23, wherein the
2 sharpness enhancement algorithm is a spatial-domain
3 algorithm.

1 26. The system as claimed in claim 23, wherein the
2 usefulness metric is calculated on a pixel-by-pixel basis.

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1 27. The system as claimed in claim 23, wherein the coding
2 complexity is defined as the product of a quantization
3 parameter and a number of bits used to code a macro block

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1 28. The system as claimed in claim 23, wherein the coding
2 complexity is defined as the product of a quantization
3 parameter and a number of bits used to code a block

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1 29. The system as claimed in claim 23, wherein the
2 usefulness metric occupies a range, a first terminus of the
3 range zero meaning no sharpness enhancement is allowed for
4 a particular pixel and a second terminus of the range
5 meaning that the pixel can be freely enhanced.

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1 30. The system as claimed in claim 23 wherein the system is
2 also applied to skipped macro blocks, the usefulness metric
3 being estimated based upon the coding complexity of
4 surrounding macro blocks or based upon the coding
5 complexity of a previous frame.

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1 31. The system as claimed in claim 23, wherein the system
 2 is also applied to uncoded blocks, the usefulness metric
 3 being estimated based upon the coding complexity of
 4 surrounding blocks or the coding complexity of a previous
 5 frame.

1 32. The system as claimed in claim 23, wherein in addition
 2 to the usefulness metric, scene-content related information
 3 is incorporated into a coding gain calculation.

1 33. The system, as claimed in claim 32, wherein the scene-
 2 content related information is derived from edge
 3 information.

1 34. The system as claimed in claim 23, wherein coding gain
 2 of a pixel is determined by the equation:

$$g_{\text{coding}}(i,j) = \text{UME}(i,j) + g_{\text{edge}}(i,j)$$

6 and wherein i and j are pixel coordinates, g_{coding} is the
 7 pixel coding gain, UME is the usefulness metric and g_{edge} is
 8 derived from edge-related information derived from the
 9 image.

1 35. The system as claimed in claim 23, wherein spatial
 2 low-pass filtering is applied to a complexity map
 3 calculated from the coded digital video stream.

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1 36. The system as claimed in claim 23, wherein temporal
 2 filtering is applied to a coding gain based upon a coding
 3 gain of a previous frame.

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1 37. The system as claimed in claim 34, wherein the
 2 equation can be extended to include an additional term
 3 directly related to the quantization parameter.

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1 38. The system as claimed in claim 36, wherein a block-
 2 based complexity map is filtered temporally using an IIR
 3 filter.

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1 39. The method as claimed in claim 36, wherein a macro
 2 block-based complexity map is filtered temporally using an
 3 IIR filter.

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1 40. The system as claimed in claim 36, wherein the
 2 temporal filtering is in accordance with the following
 3 equation:

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5. $\text{compl}_{\text{MB/block}}(r,s,t) = k * \text{compl}_{\text{MB/block}}(r,s,t) + \text{scal} * (1 -$
6 $k) * \text{compl}_{\text{MB/block}}(r,s,t-1)$

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8 and wherein r,s is the spatial coordinate of a macroblock
9 (MB) or block, t represents the current picture, k is the
10 IIR filter coefficient and scal is a scaling term taking
11 into account picture complexity determined by the image's
12 picture type.

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1 41. Computer-executable process steps to enhance image
2 quality, the computer-executable process steps being stored
3 on a computer-readable medium and comprising:

4 an extracting step to extract statistical information
5 from a coded video bit stream in order to identify a
6 video's coding complexity;

7 a generating step to generate a usefulness metric for
8 a coded video based upon the coding complexity, which
9 identifies a limit to sharpness enhancement that can be
10 applied to the coded video after decoding without enhancing
11 coding artifacts; and

12 an enhancement step to enhance the sharpness of the
13 image by applying a sharpness enhancement algorithm to a
14 decoded video to increase sharpness within the limit
15 prescribed by the usefulness metric.

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1 42. Means for enhancing the sharpness of a coded digital
2 video, comprising:

3 extracting means for extracting statistical
4 information from a coded video bit stream in order to
5 identify the coded digital video's coding complexity;
6 generating means for developing a usefulness metric
7 for the coded digital video, based upon the coding
8 complexity, which identifies a limit to sharpness
9 enhancement that can be applied to the coded digital video
10 after decoding without enhancing coding artifacts; and
11 enhancement means for applying a sharpness enhancement
12 algorithm to a decoded video to increase sharpness within
13 the limit prescribed by the usefulness metric.

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1 43. A signal, embodied in a carrier wave, representing data
2 for enhancing sharpness of a decoded digital video,
3 comprising:

4 statistical information selected from a coded video
5 bit stream to be used in identifying the complexity of a
6 video;

7 a usefulness metric, based upon the complexity of the
8 video, which identifies a limit to sharpness enhancement

9. which can be applied to the decoded video without enhancing
coding artifacts; and
a sharpness enhancement algorithm to be used for
increasing the sharpness of the decoded video within the
limit prescribed by the usefulness metric.

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1 44. A method for enhancing image quality comprising the
2 steps of:

3 peaking filtering a coded luminance signal, increasing
4 the amplitude of the luminance signal and generating a high
5 pass signal;

6 calculating at least one maximum gain factor for the
7 luminance signal, based on a characteristic of the
8 luminance signal, wherein at least one gain factor
9 calculation implements a usefulness metric which determines
10 an allowable amount of peaking which will not intensify
11 coding artifacts;

12 selecting a minimum gain from the maximum gain
13 factors;

14 multiplying the high pass signal by the minimum gain
15 generating a multiplied signal; and
16 adding a decoded luminance signal with the multiplied
17 signal, generating an enhanced signal.

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1. 45. A video receiving device comprising:
 - 2 a peaking filter which filters a decoded luminance
 - 3 signal, generating a high pass signal;
 - 4 a plurality of pixel based control blocks, operating
 - 5 in parallel on the decoded luminance signal, each
 - 6 calculating a maximum allowable gain factor, based upon a
 - 7 characteristic of the luminance signal, wherein at least
 - 8 one control block is a coding gain block which implements a
 - 9 usefulness metric which determines the allowable amount of
 - 10 peaking;
 - 11 a dynamic gain control for selecting a minimum gain
 - 12 based upon the calculated maximum gain factors;
 - 13 a multiplier for multiplying the high pass signal by
 - 14 the minimum gain generating a multiplied signal; and
 - 15 an adder for combining the decoded luminance signal with
 - 16 the multiplied signal, generating an enhanced signal.
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